INERTIAL CONFINEMENT FUSION
Lawrence Livermore National Laboratory
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National Ignition Facility High-speed Jet Experiments

High-speed jets of material created by the interaction of strong shock waves with spatially localized density nonuniformities are seen in many astrophysical systems. They are also predicted to occur in Inertial Confinement Fusion (ICF) capsule implosions due to the presence of features such as hemispherical joints and gas-fill tubes. The behavior of these jets has recently been studied experimentally in mm-scale shock tubes on the National Ignition Facility (NIF) laser. These are the first hydrodynamics experiments performed on NIF. The experiments required the construction and commissioning of a gated x-ray detector and a separate backlighter target positioner, development of new nondestructive characterization tools, and development of a new backlighting geometry.

In these experiments, two NIF laser beams of were used to create a high Mach number supersonic jet. Each beam provided about 1.2 kJ of 0.35-μm light in 1.5 ns. In this geometry, the laser beams strike the ablator and generate a very strong blast wave, which traverses the uniform part of the aluminum cylinder and interacts with the hole. The pressure in the aluminum is 20-60 Mbar (depending on the position in the aluminum, with the side nearest the foam at the lower pressure). The Mach No. of the shock in the aluminum was approximately 8. The interaction of the blast wave with the void generates a jet of material, which exits the hole and interacts with the carbon foam.

The target, as shown in Fig. 1b, consisted of a polystyrene ablator 50-μm thick, a cylindrical aluminum disk 250-μm thick with a central hole 160 μm in diameter and 200-μm deep, and a foam (0.1 g/cc carbon) cylinder 800 μm in diameter contained within a thin-walled polystyrene shock tube.

The entire target assembly was characterized using a non-destructive characterization tool. X-ray images of the void were taken in multiple views. This provides information on the target process and a characterization of the actual target.

A third laser beam, delayed in time by 21.6 ns, was used to create a point x-ray source. Point-source radiography is important to create a large, uniformly illuminated field of view for the experiment. A new geometry for point-source radiography was developed to reduce the effects of debris. The pinhole substrate is tilted relative to the target and detector as shown in Fig. 1a.

The image of the jet structure taken with a gated microchannel plate detector is shown in Fig. 1c. Clearly visible as different transmission levels are the aluminum, the shock in the foam in regions unaffected by the jet, the jet of aluminum, and the bow shock of the jet. At this time the aluminum-foam interface has moved ~320 μm, the shock has moved ~60 μm ahead of the aluminum, and the jet is ~320-μm tall, 360 μm across the cap, and ~110 μm across the stem. Asymmetries in the jet shape are attributed to shock nonuniformity and will be investigated further in the next series of experiments.

Additional experiments in this series replaced the symmetric void with a void tilted at 45º, which may only be modeled with three-dimensional codes. Experiments are planned in May to further investigate two- and three-dimensional structures with improved laser uniformity and increased energy. These experiments challenge two- and three-dimensional code capabilities and demonstrate the ability to perform complex exper-iments on NIF. This work was done in collaboration with the Defense and Nuclear Technologies Directorate.

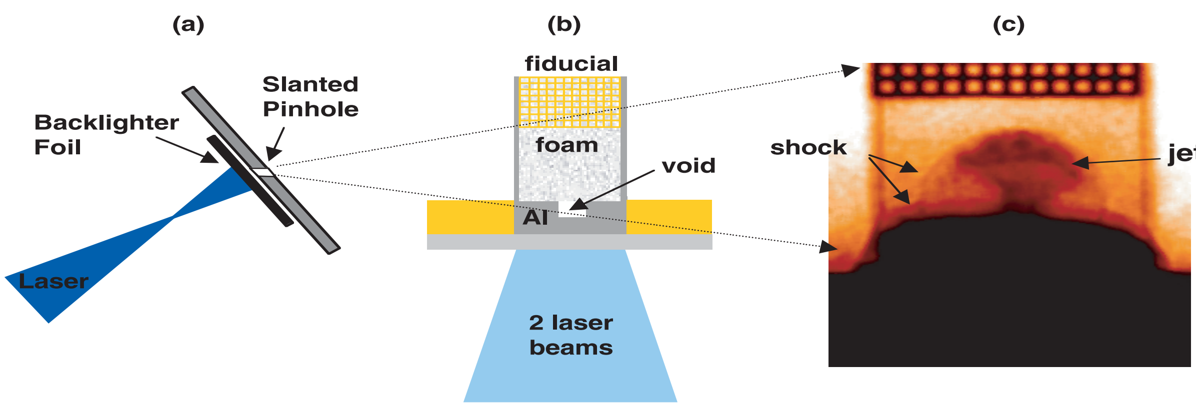

Figure 1. Schematic of the target. (a) Backlighter geometry. (b) Target. (c) X-ray radiograph at t = 21.6 ns. The laser drive was 2.3 kJ delivered in a 1.5-ns square pulse.

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